PCT/AU00/00281

4

PRIORITY DOCUMENT

SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

Patent Office
Canberra

I, LEANNE MYNOTT, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. PP 9573 for a patent by MICHAEL JOHN RAFFAELE and PETER ROBERT RAFFAELE filed on 01 April 1999.

REC'D 20 APR 2000
WIPO PCT

COMMONWEALTH OF AUSTRALIA
AUSTRALIA
PATENT OFFICE

WITNESS my hand this
Eleventh day of April 2000

L. Mynott

LEANNE MYNOTT
TEAM LEADER EXAMINATION
SUPPORT AND SALES

AUSTRALIA
Patents Act 1990
PROVISIONAL SPECIFICATION
FOR A PROVISIONAL PATENT

Name of Applicant: **MICHAEL JOHN RAFFAELE & PETER ROBERT RAFFAELE**
Actual Inventor: **MICHAEL JOHN RAFFAELE & PETER ROBERT RAFFAELE**
Address for Service:

Chrysiliou Moore Martin
CMC Centre
143 Sydney Road
Fairlight
Sydney NSW 2094

Invention Title: **Improvements To Reciprocating Fluid Devices**

The following statement is a description of this invention

e:\work\9904m001.docmm

This invention relates to a variation of reciprocating fluid machines colloquially called "scotch yoke" devices.

Known scotch yoke devices comprise one or more pairs of horizontally opposed pistons reciprocating in respective cylinders. Each piston of a pair is rigidly attached to the other so the pair of pistons move as a single unit. The pistons reciprocate along parallel axes which may be coaxial or which may be offset. A crank is provided centrally of the pair of pistons with an offset mounted in a slider. The slider in turn is mounted in the piston assembly between opposing sliding surfaces, which extend perpendicular to the axes of the pistons. The slider is thus constrained to move perpendicular to the piston axes and so, as the crank rotates, the pistons are caused to reciprocate along the piston axis, with a true sinusoidal motion. In certain circumstances the provision of a true sinusoidal motion is preferable to the quasi- sinusoidal motion provided by a crank and connecting rod arrangement found in most internal combustion engines or pumps. However such devices have certain drawbacks. Neither the slider, which reciprocates in a vertical place, nor the pistons, can be dynamically balanced by a rotating mass. Whilst this can be partially compensated for in a multi-pair device, this still leaves rocking couples.

Further in the conventional arrangement the slider slides between a single pair of opposed surfaces which lie on either side of the big end bearing. The pistons must be arranged along parallel axes and the distance between the sliding surfaces of the slider and the guide surfaces of the pistons must be larger than the diameter of the big end on the crank.

The present invention aims to at least meliorate some of the disadvantages of the prior art and, in preferred forms, provides devices in which paired pistons are not rigidly connected together, are not necessarily coaxial and in which better dynamic balancing is achieved. The invention also allows use of uneven numbers of pistons mounted on a single big end bearing pin.

In its broadest form the invention de-couples the pistons from each other and provides each piston with its own pair or group of sliding surfaces and its own slider. The sliding surfaces for each piston do not lie on either side of the big end but are positioned remote from the big end. The sliding surfaces may be compound surfaces. This decoupling means that each piston is not relying on the coupling with the other piston or pistons to move in both directions and allows the pistons to move along separate axes and at different phases to all other pistons.

Whilst pistons may be interconnected via a common linkage which carries the various sliding surfaces, the pistons are not rigidly connected together. Thus a V-configuration may be achieved with a pair of pistons or a 120° layout with three pistons, for instance.

In one broad form the invention provides a fluid engine or pump, which includes:

a crank mechanism including a big end bearing which orbits about a main axis;

connecting means rotatably mounted on the big end bearing;

at least two pistons, each mounted for reciprocal motion in respective cylinders along a respective piston axis, each piston including at least two linear parallel opposed guide surfaces which each engage a respective engagement means on the connecting means, said guide surfaces both being disposed on the same side of the big end bearing.

Preferably, the guide surfaces extend substantially perpendicular to the respective piston axis. However, the guide surfaces may extend at other than 90° to the respective piston axis. The guide surfaces may deviate from the perpendicular by up to 5° either way. The engagement means may be two or more parallel linear surfaces which correspond and slide relative to the guide surfaces. Alternatively, the engagement means may include two or more roller bearings or the like.

The linear parallel opposed guide surfaces may be located on the connecting means and the engagement means may be mounted on the piston. In preferred forms there are two or three pistons mounted on slider means on each big end bearing. The pistons may be arranged at equal angles about the main axis if desired.

The guide surfaces may be integral with the piston or may be located on a separate structure attached to the piston. Where a separate structure is provided, it may be pivotably mounted to the piston, preferably using a gudgeon pin arrangement. This allows one to use conventional pistons with connecting rods incorporating the guide surfaces.

The crankshaft may be fixed relative to the cylinders or may be movable so as to alter the compression ratio and/ or the timing of the pistons in the cylinders. In a V configuration, movement of the crankshaft along the bisector of the included

angle between the cylinders results in a change in compression ratio without any change in phase. An alternate arrangement provides for the crankshaft axis to rotate about a distant axis, so raising or lowering the crankshaft.

When two pistons per big end bearing are utilised the pistons may be arranged in a V-configuration. The V-configuration may be at any angle, such as 90°, 60°, 72° or any other desired angle. The number of pistons per big end bearing is only constrained by physical size limitations. Each big end bearing may have a single connecting means upon which multiple pistons are mounted or there may be a multiple connecting means mounted on each big end bearing with each connecting means having an associated piston mounted upon it.

When multiple pistons are mounted to one big end bearing, they may be located the same distance from the main axis or different pistons may be at different distances from the main axis.

Whilst the guide surfaces and complimentary engagement means are preferably simple planar surfaces, in cross section, other configurations are possible, to provide additional locating surfaces perpendicular to the line of the guide surfaces.

The invention, in another broad form, also provides a fluid engine or pump, which includes:

> a crank mechanism including a big end bearing which orbits about a main axis;
>
> connecting means rotatably mounted on the big end bearing;
>
> at least one piston mounted for reciprocal motion in a cylinder along a piston axis, the at least one piston engaging an engagement means on the connecting means; and,
>
> stabilising means engaging the connecting means to limit the connecting means to a single orientation as it orbits the main axis.

The stabilising means may include the engagement of the connecting means with the at least on piston. The stabilising means may include a separate linkage pivotably mounted to both the connecting means and the crankcase.

The crank mechanism may be a simple crank with an offset big end bearing or it may be a compound mechanism which provides for other than simple circular motion of the big end bearing at a constant angular velocity. Examples of compound crank mechanisms are disclosed in PCT International Patent Application Nos. PCT/AU97/00030 and PCT/AU98/00287, the disclosures of which are incorporated herein.

The invention, in another broad form, also provides a fluid device, which includes:

a crank mechanism including a big end bearing which orbits about a main axis;

connecting means rotatably mounted on the big end bearing;

at least one piston mounted for reciprocal motion in a respective cylinder along a piston axis, the at least one piston engaging engagement means on the connecting means;

said main axis of the crank mechanism movable along at least one path relative to said cylinder or cylinders and said engagement means configured such that said at least one piston is neither substantially retarded or advanced.

Where the device includes pistons arranged in a V configuration the main axis of the crank mechanism preferably moves along a linear path which bisects the included angle of the V. Alternatively, the main axis of the crank mechanism may move along an arc.

The invention shall be better understood from the following, non-limiting description of preferred forms of the invention, in which:

Figure 1 is a cross-sectional view of a fluid machine according to the invention.

Figure 2 is a partial cutaway perspective view of the Figure 1 device.

Figure 3 is a perspective view of a three piston fluid machine according to the invention.

Figure 4 shows an end view of a third embodiment of the invention.

Figure 5 shows a partial cutaway perspective view of a fourth embodiment of the invention.

Figure 6 shows an end view of a connecting device of the fig 5 device.

Figure 7 shows a perspective view of the fig 6 device.

Figure 8 shows an end view of a variation of the Figure 1 embodiment.

Figure 9 shows a perspective view of a fifth embodiment of the invention.

Figure 10 shows an end view of the Figure 9 embodiment.

Figure 11 shows an end view of a sixth embodiment of the invention.

Figure 12 shows an end view of a seventh embodiment of the invention.

Figure 13 shows an end view of a eighth embodiment of the invention.

Figures 14 to 29 show various configurations of the guide surfaces of the invention.

Referring to Figures 1 and 2 there is shown a fluid device 10 which includes a crank 12 mounted for rotation about a crank axis 14. The crank 12 has an offset bearing pin 16, radially distant from the axis 14. Thus as the crank 12 rotates about axis 14, pin 16 will describe a circular orbit around axis 14.

Rotatably mounted on bearing pin 16 is a slider 18. The slider has two tongues 20, 22.

The slider 18 extends generally perpendicular to the axis 14 whilst the tongues extend generally parallel to the axis 14. As best seen in Figure 2 the sliding surfaces extend axially on either side of the main portion 24 of the slider and so form a T-shaped construction.

Each of the tongues 20, 22 engages in a T-shaped slot 30 of a respective piston 32. Each piston is mounted in a cylinder 34 and constrained for linear movement along respective cylinder axis 36. The slot 30 preferably extends substantially perpendicular to the cylinder axis 36 and extends diametrically across the centre of the piston. Both ends of the slot 30 are open. The slider can thus move sideways relative to the piston but must move axially with the piston. Where the slot 30 does not extend at 90° to the piston axis, sideways movement of the

tongue relative to the piston will cause axial motion of the piston. This enables one to control the motion of the piston beyond a pure sinusoidal motion.

The piston is constrained to move along its piston axis and as the crank 12 rotates the slider 18 member rotates about the crank axis 14. The motion of each tongue has a component parallel to the respective piston axis and a component perpendicular to the respective piston axis. Thus, the pistons reciprocate in their respective cylinders with the tongues sliding sideways in their respective slots 30. The combination of the linear movement of the piston and the tongue in the slot maintains the slider member 18 in a constant orientation as the crank rotates, irrespective of other pistons. In the embodiment of Figure 1, there are provided two pistons at 90° to each other, but since the slider 18 maintains its orientation as it orbits the crank axis, the angle between the pistons may be other than 90°. Similarly more pistons may be added.

Figure 3 shows a perspective view of a three piston device. For clarity the cylinder and crank cast assemblies are omitted. As can be seen, the device 110 includes a crank 112 with a bearing pin 116 extending between webs 117. Three pistons are arranged equally about the crank at 120° to each other. Mounted on the bearing pin is a triple tongue device 118. This device may be a unitary structure or it may comprise three separate components mounted on the pin 116. As seen, each piston is provided with a T-shaped slot 130 into which the respective tongue 120 engages. The pistons are axially offset but, if desired, they may be in a common plane.

Because each of the pistons is decoupled from any other piston, the orientation and position of the pistons may be chosen as desired. There is no need for the piston axes to extend radially from the crank axis. The piston axes may extend radially from an axis, but this axis may be remote from the crank axis. The piston axes may be parallel and spaced from each other on either side of the crank axis.

Figure 4 shows a fluid device 50 having a crank 52 rotating about crank axis 54. A slider mechanism 56 is maintained on a bearing pin 56 and has two arms 58, 60 which extend horizontally and engage in slots 62, 64 respectively of pistons 66, 68. Each of the pistons 66, 68 reciprocates in a dual chambered cylinder 70, 72. The cylinders 70, 72 are closed at both ends and thus combustion chambers 74 are defined between the pistons and the ends of the cylinders.

Rotation of the crank 52 causes the pistons to reciprocate vertically within the cylinders with the arms moving sideways relative to the pistons.

Referring to figures 5 to 7 there is show a reciprocating piston device 210 having two pistons 230 reciprocating in respective cylinders 234 at 90° to each other. A connecting device 218 connects the two pistons to big end pin 216 of crankshaft 212 via tongues 220 and slots 230 in the pistons 232. The connecting device 218 has two webs 240, one for each piston, which are offset axially relative to each other. This allows the pistons 232 to overlap each other and so be brought closer to the crank axis 214. Lubrication ducts 242 are provided to supply pressurised oil from the big end pin 216 to the sliding surfaces of the tongues 220and slots 230.

The connecting device 218 includes a counter weight 244 extends downwardly on the opposite side of the big end pin 216, bisecting the angle between the two webs 240. This counter weight 244 is sized so that the centre of inertia and preferably also the centre of mass of the connecting device 218 lies on the big end axis 246. It will be appreciated that when the pistons are spaced equally about the crank axis 214 that the webs 240 will balance each other and a separate counter weight may not be needed.

As the connecting device orbits the crank axis 214 no rotational forces are generated relative to the big end axis 246, which would cause the connecting device to attempt to rotate about the big end and which would need counter turning forces to be generated at the slot 230 / tongue 220 interface. In addition, since the centre of inertia of the connecting device remains on the big end axis 246, it is a relatively simple matter of adding an appropriate amount of mass to the counter weight 248 on the crank 212 diametrically opposite the big end axis 246 to provide a dynamically balanced crankshaft/connecting device combination. It will be appreciated that for other piston arrangements that so long as the connecting device's centre of inertia lies on the big end axis 246, then it may be dynamically balanced.

This leaves the reciprocating mass of the pistons. The velocity of the pistons follows a pure sinusoidal path and in combination the two pistons are the equivalent of a single rotating mass. This may be balanced by adding an appropriate mass to the crankshaft, thereby resulting in a dynamically balanced device. For a V twin configuration, a single piston mass is added to the back of the crankshaft. For a four piston star configuration, two piston masses are added to the crank counter weight.

Referring to figure 8, there is show a fluid device 50 which is a variation on the figure 1 embodiment. For clarity the same numbers are used for the same components. The combination of the piston 32 being limited to linear motion along the piston axis 36 and the respective tongue 20 being limited to linear motion relative to the piston 32 theoretically prevents any rotation of the connecting means 18 relative to the piston 32. However, due to the need for manufacturing tolerances, there will inevitably be some free-play and hence turning of the connecting means 18 relative to the pistons 32. This in turn will generate turning forces at the interfaces of the tongues 20 with the slots 30. To alleviate this, the device in figure 8 is provided with a linkage 40. One end of this linkage 40 is pivotably connected to the connecting means 18 at 42 and its other end is pivotably connected to the crankcase (not shown) at 44. The linkage 40, connecting means 18, crankshaft 12 and crankcase thus for a four bar linkage. The distance between the two pivot points 42, 44 is the same as the separation of the crank axis 14 from the big end axis 46. Thus, irrespective of the restriction imposed by the engagement of the connecting means 18 with the pistons 32, the connecting means is constrained to orbit about crank axis 14 without changing its orientation.

Referring to figures 9 & 10 there is shown a twin cylinder fluid device 60 having pistons 62 reciprocating in cylinders 64. The pistons 62 are each provided with a gudgeon pin 66 mounted in a bearing 68 on the respective piston. Mounted on the gudgeon pin 66 is a connecting rod 70. However, the connecting rod 70 does not mount on the big end of the crankshaft 12, but on the connecting means 18. The lower end 72 of the respective connecting rod 70 is provided with a T-shaped slot 74 which receives the T-shaped tongues 20 of the connecting means 18. Whilst the connecting rod 70 is free to rotate about the gudgeon pin 66 relative to the piston, the combination of the planar mating surfaces of the slots 74 and tongues 20 prevents any pivoting and so the connecting rod 70 and connecting means 18 move as a single unit. Whilst this mat appear to introduce unnecessary complication to the structure, it does allow one to use conventional pistons.

Referring to figure 11, there is shown a twin cylinder fluid device 80 with twin pistons 82 mounted on connecting means 18 in cylinders 84. The connecting means 18 is mounted on a crankshaft 12, but the axis 14 of the crankshaft is not fixed relative to the cylinders 84. Instead, the crankshaft 12, and with it connecting means 18 and pistons 82 may be moved upwards or downwards, as indicated by arrows 86. The vertical movement of the crankshaft 12 raises the pistons in the cylinders 84 and thus provides the ability to vary the compression

ratio on the fly. Movement of the crankshaft 12 does not effect the timing of the pistons in the cylinders 84 relative to the crankshaft 12 or to each other. This is in contrast to conventional V engines which if provided with movable cranks, causes the timing of the pistons to vary, with one piston being advanced and the other retarded.

Vertical movement of the crankshaft 12 may be achieved utilising conventional means, such as hydraulic rams or the like.

Figure 12 shows a variation of the figure 11 embodiment, in which the crankshaft 12 is mounted on bearing arms 90. The crank engages a gear 92, which may be connected to a gearbox in the case of an engine. The gear 92 has an axis of rotation 94. The bearing arms 90 are pivotably mounted on the crankcase about axes which are coaxial with the axis 94. The bearing arms may be rotated about the axis 94 by suitable means to raise or lower the crankshaft relative to the cylinders. Whilst this does cause a sideways movement of the crankshaft, and so advancement and retardation of the pistons, this is very slight.

Figure 13 shows a further embodiment of the invention, in which there is a twin cylinder device 100 with pistons 102 reciprocating in cylinders 104. The pistons have connecting rods 106 pivotably mounted on gudgeon pins 108. The lower end of the connecting rod is provided with two opposed parallel surfaces in which a slider 110 is mounted. The opposite ends of the slider 110 are connected to hydraulically operated rams 112. These rams 112 are incorporated within the connecting means 18 and are selectively supplied with high pressure oil via ducts 114. The rams 112 are thus capable of causing the slider 110 to pivot about its centre 116, to raise or lower relative to the connecting means 118, and hence relative to the cylinder, or a combination of both. This causes the piston to rise or fall relative to the respective cylinder and/or for the connecting rod 106 to pivot about gudgeon pin 108, so altering the phase of the piston.

Figures 14 to 29 show a number of variations of the guide surfaces of the piston and the corresponding surfaces on the engagement means.

It will be apparent to those skilled in the art that many modifications and variations may be made to the embodiments described herein without departing from the spirit or scope of the invention.

Dated this 1st day of April 1999

MICHAEL JOHN RAFFAELE & PETER ROBERT RAFFAELE

by their Patent Attorneys

CHRYSILIOU MOORE MARTIN

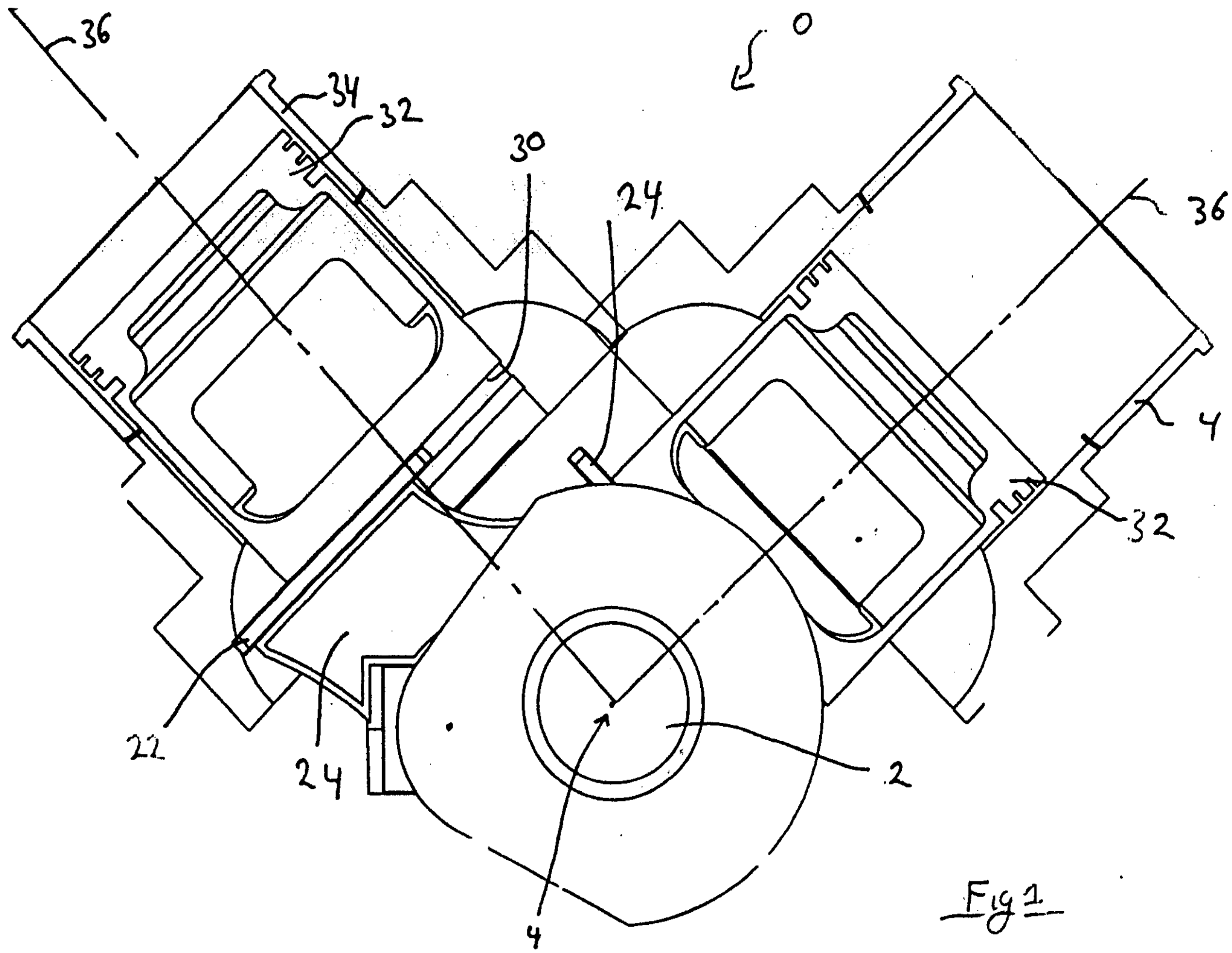


Fig 1

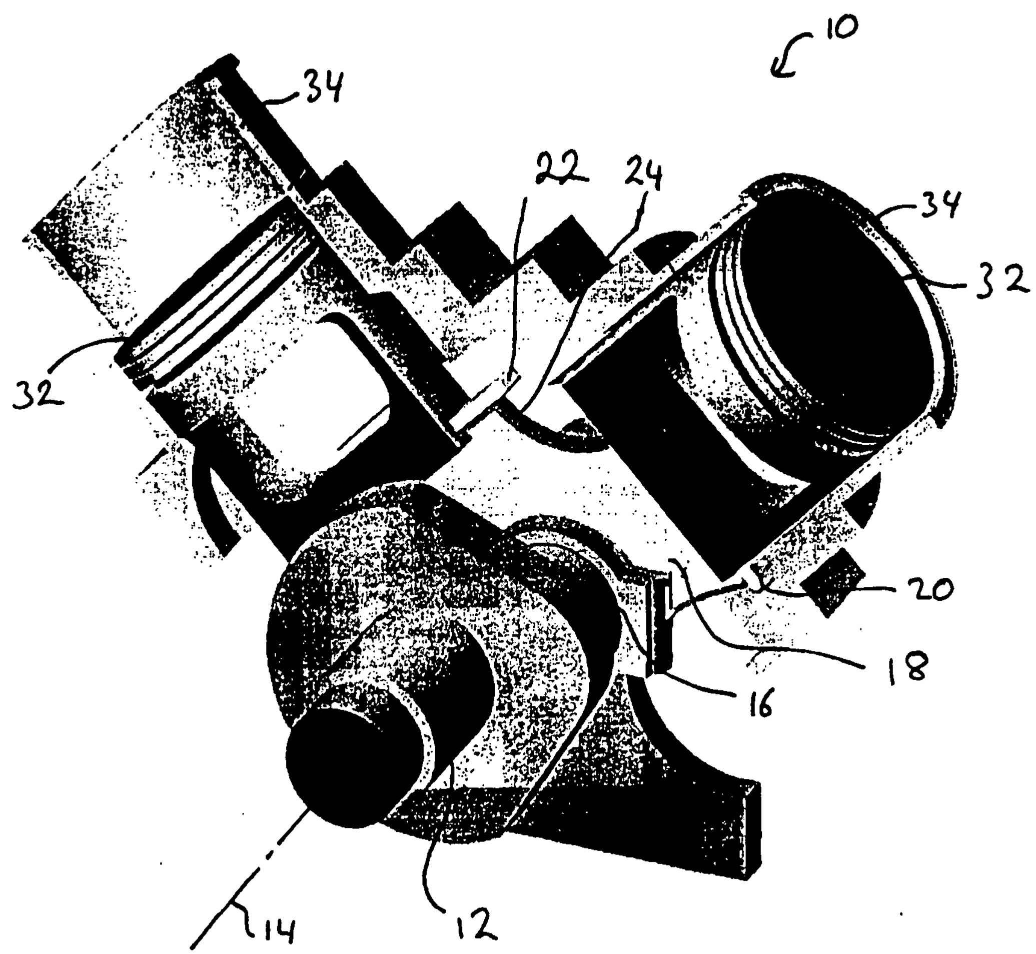


Fig2

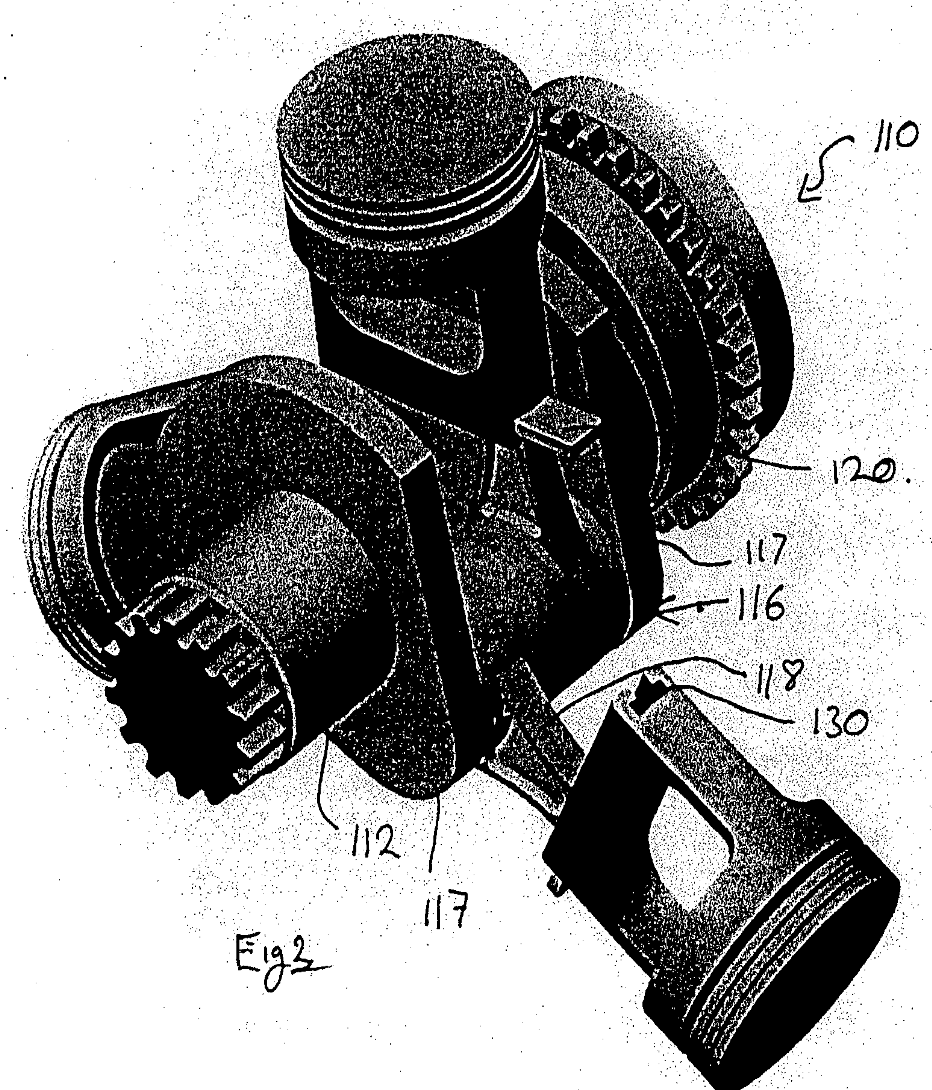


Fig 2

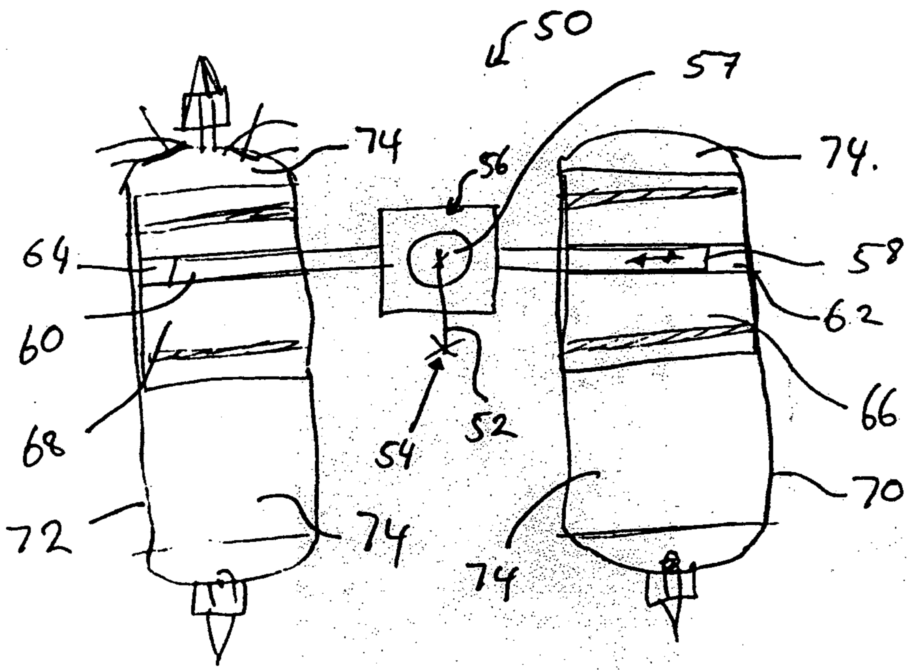


Fig 4.

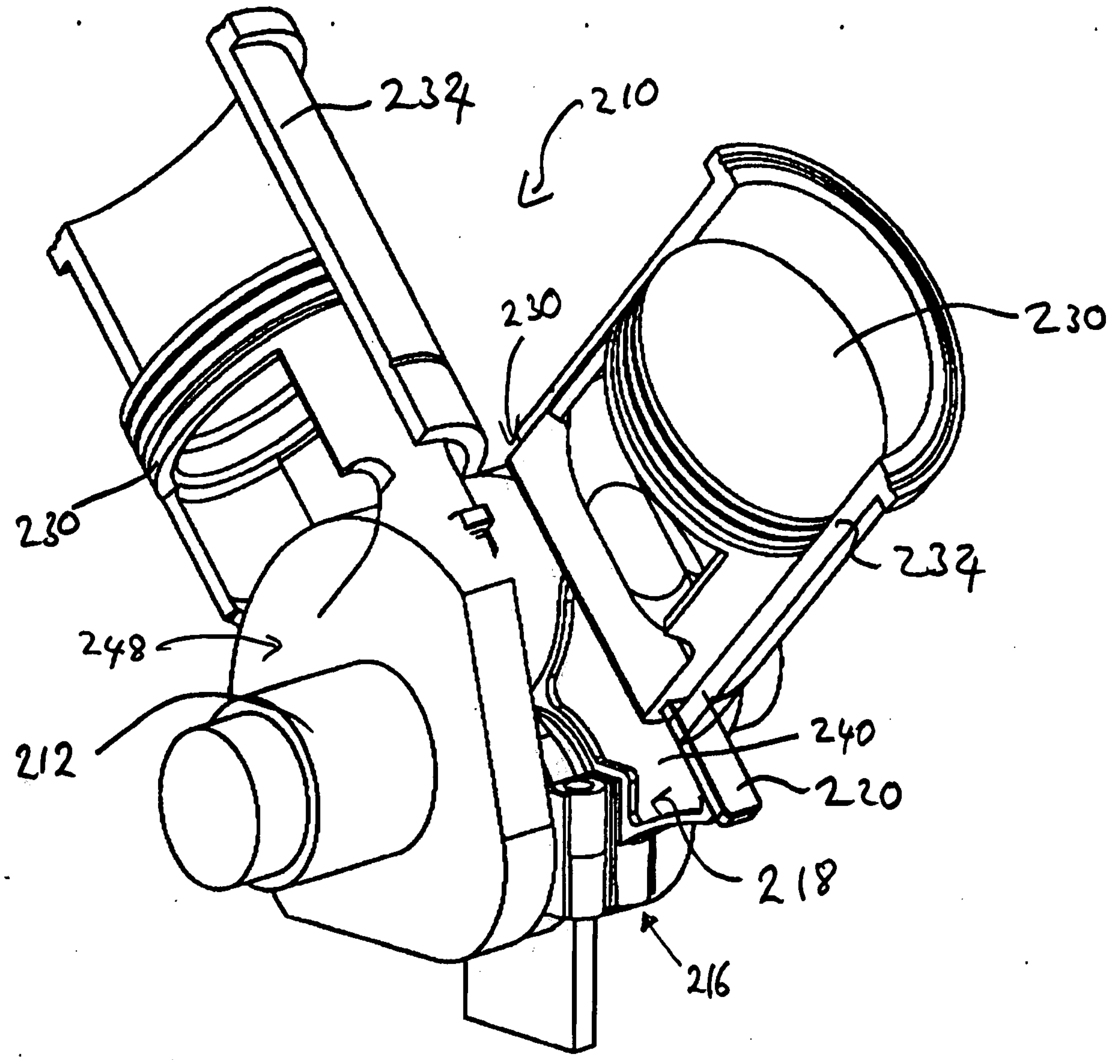


Fig 5

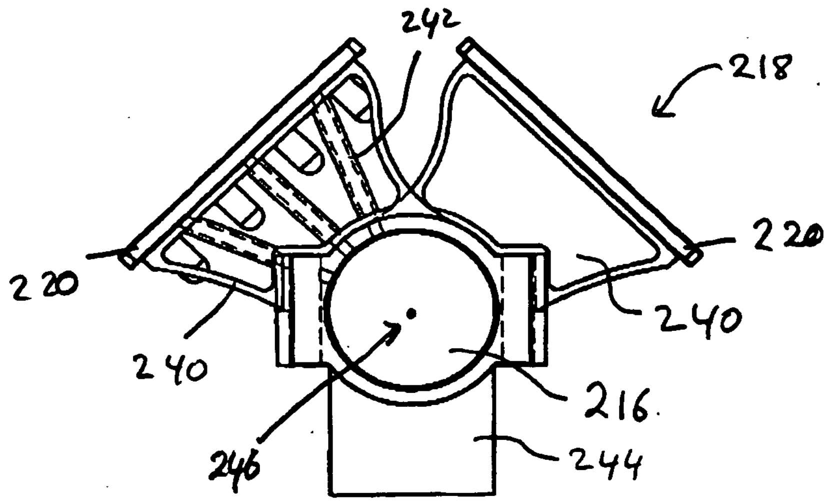


Fig6

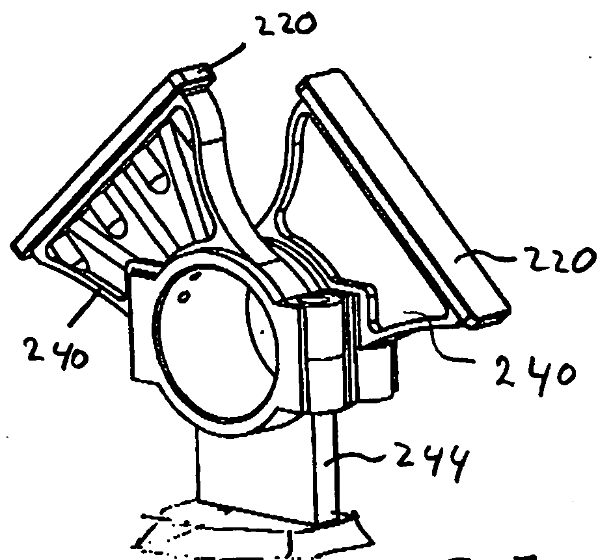


Fig 7

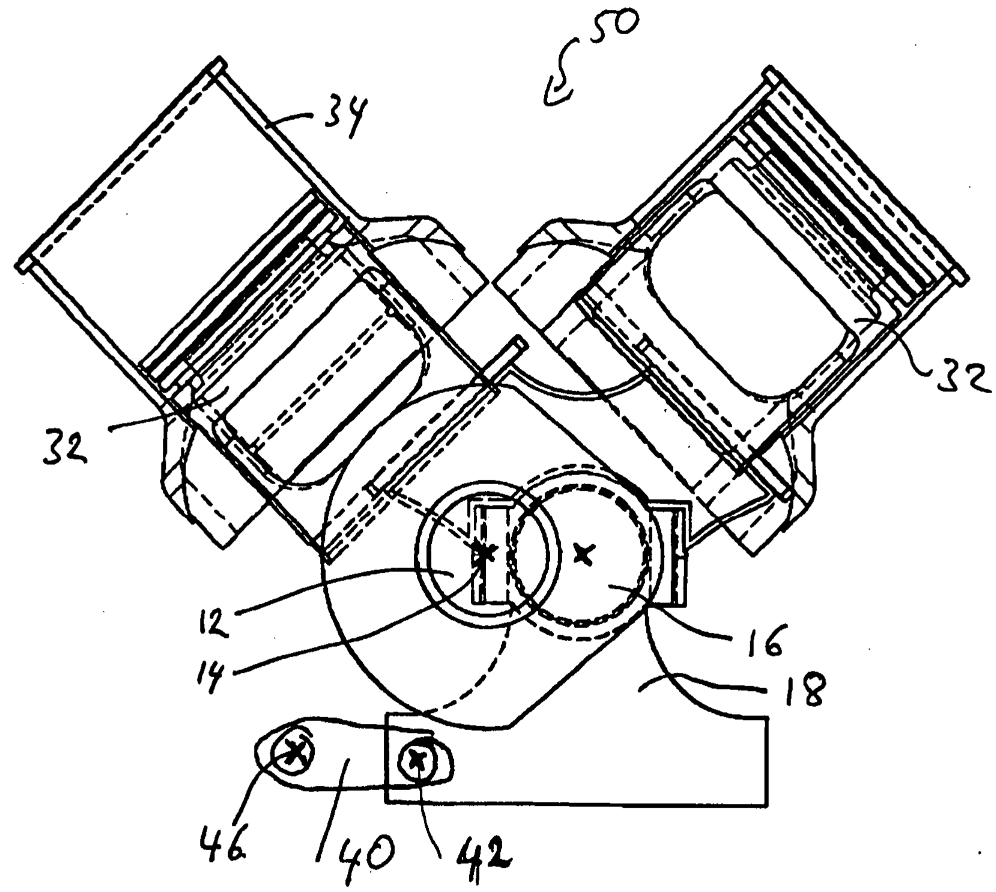


Figure 8

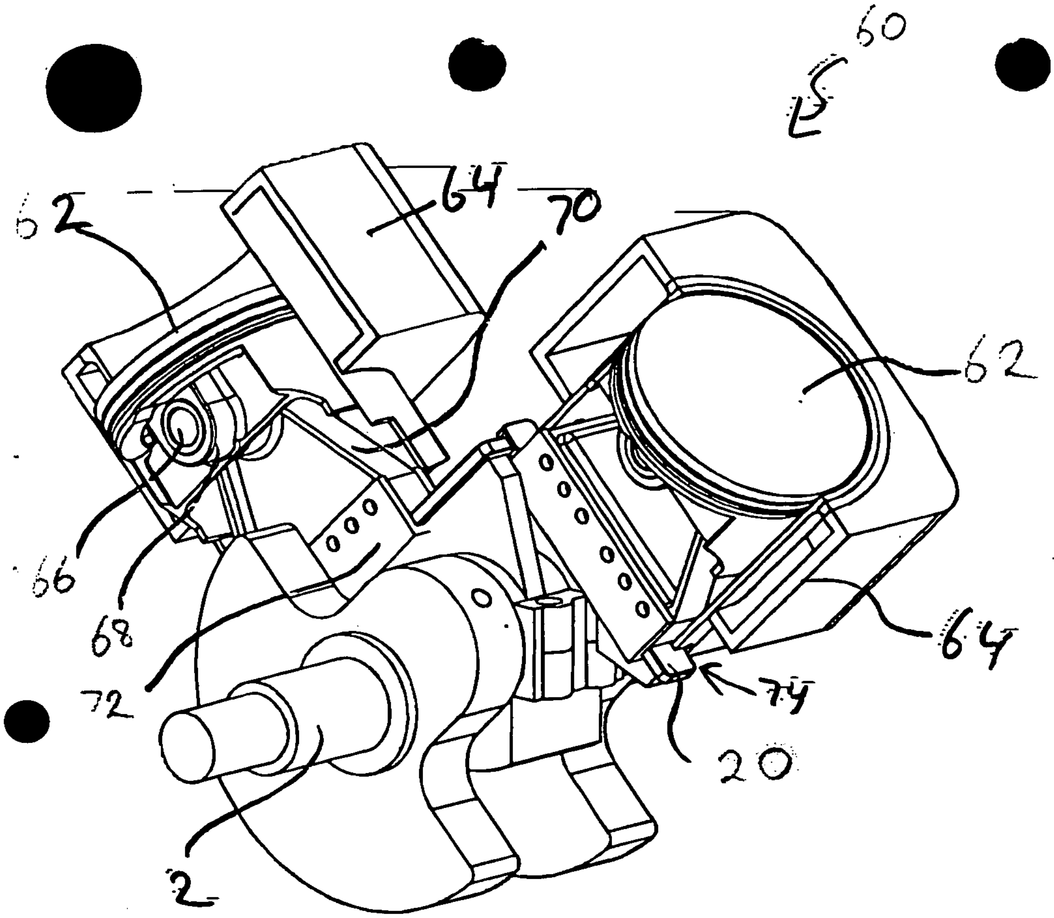


Fig 9

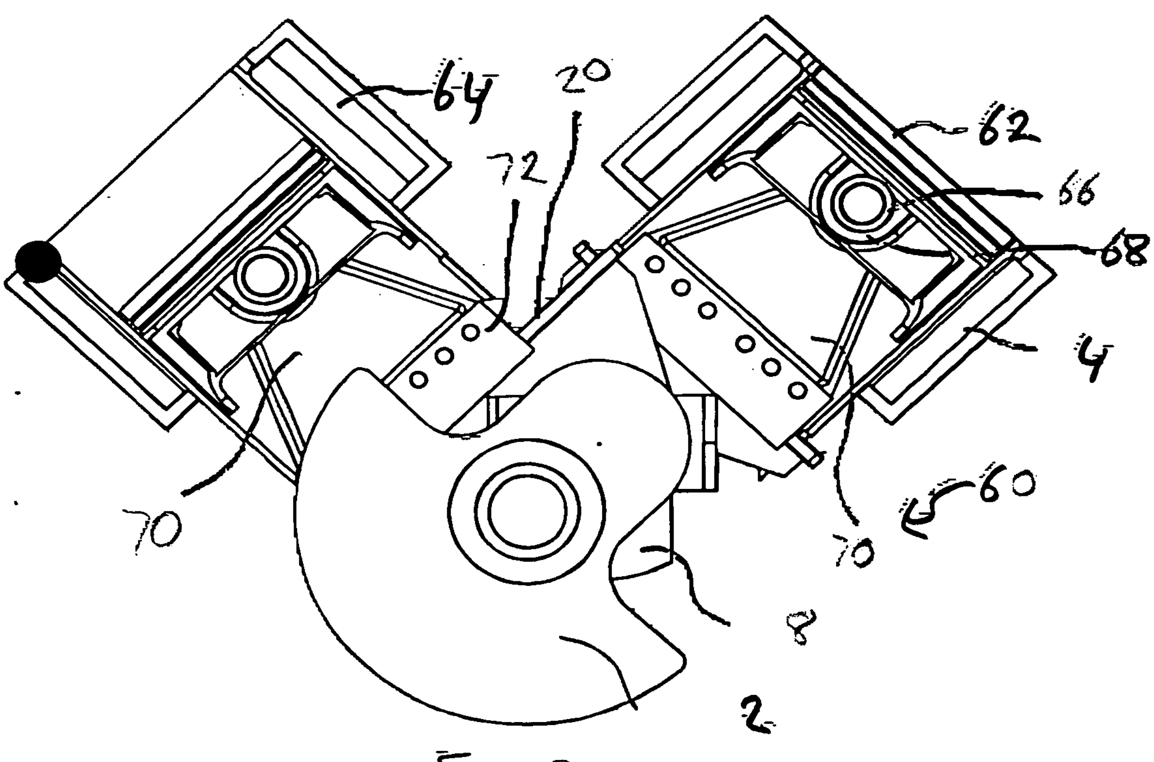


Fig 0

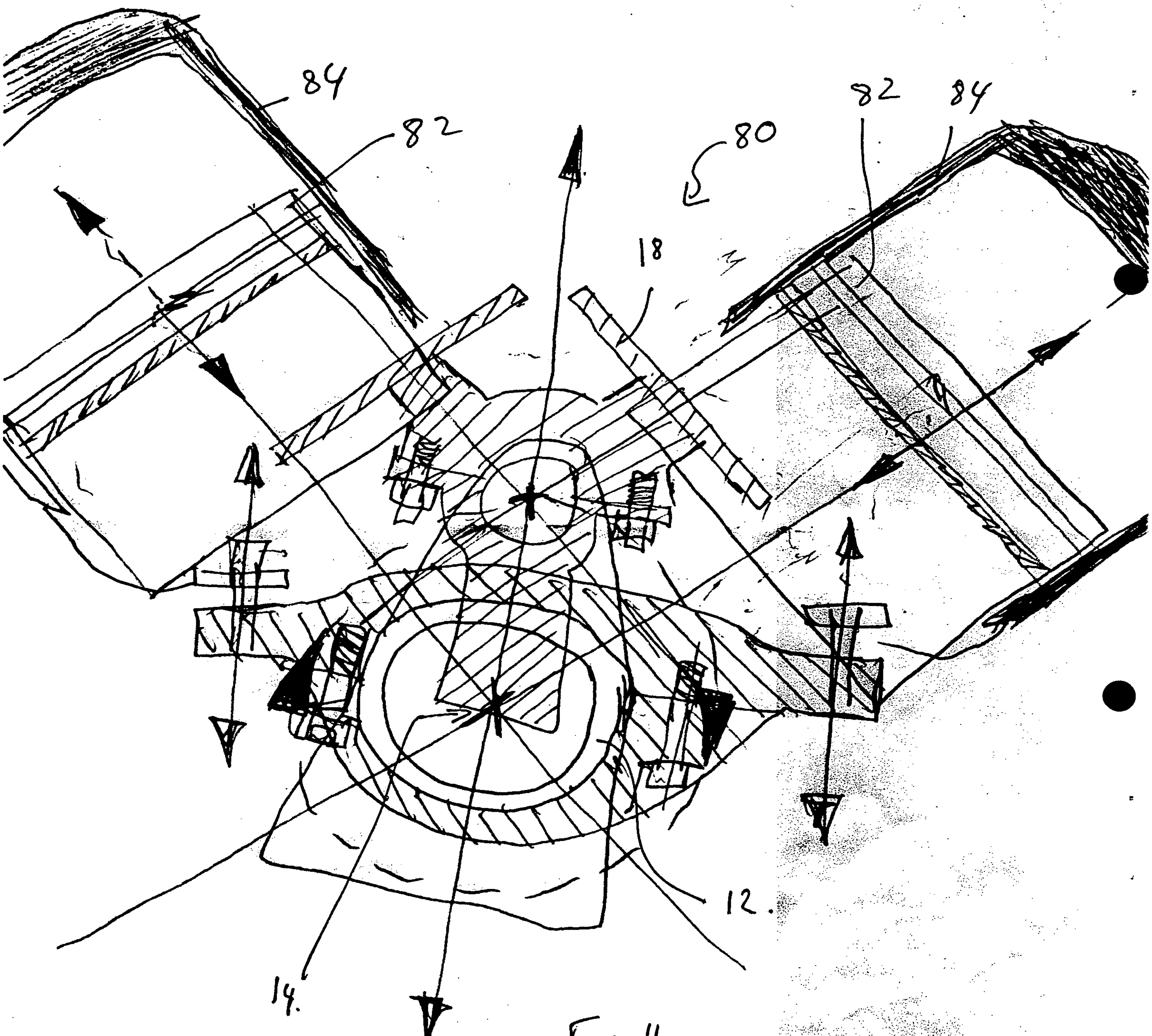


Fig 11

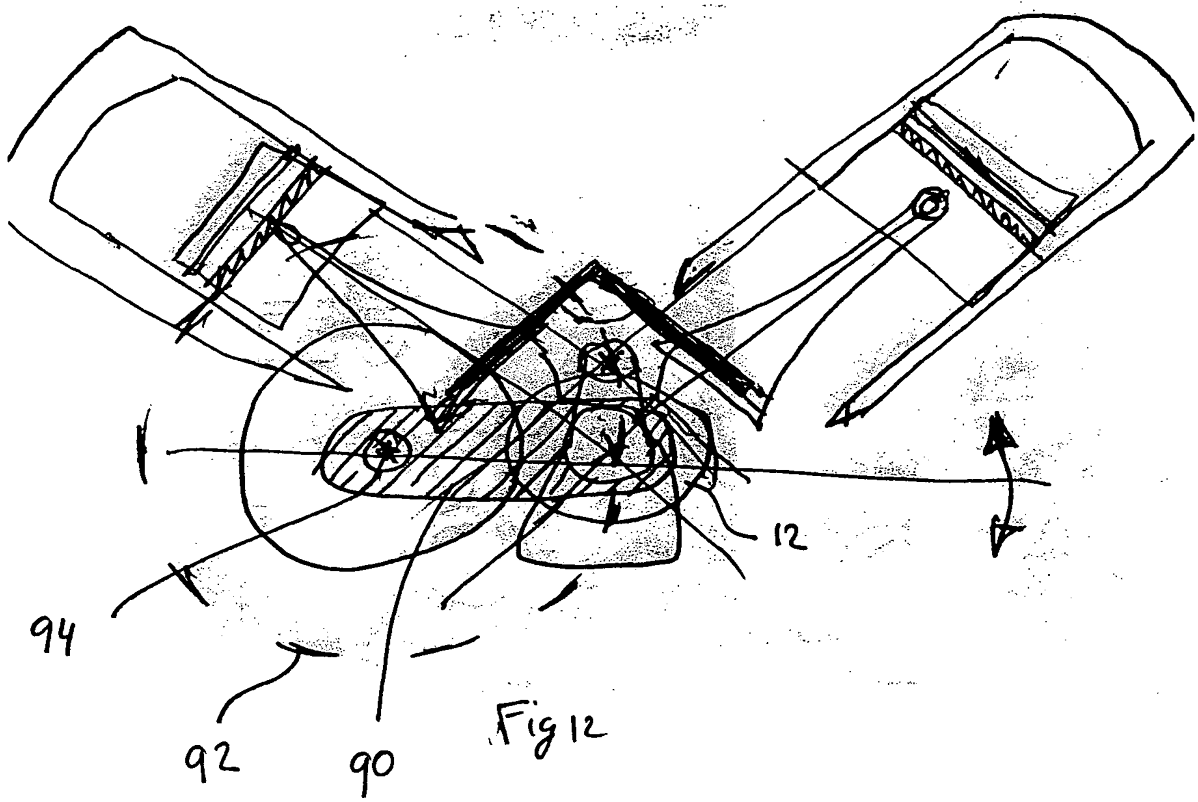


Fig 12

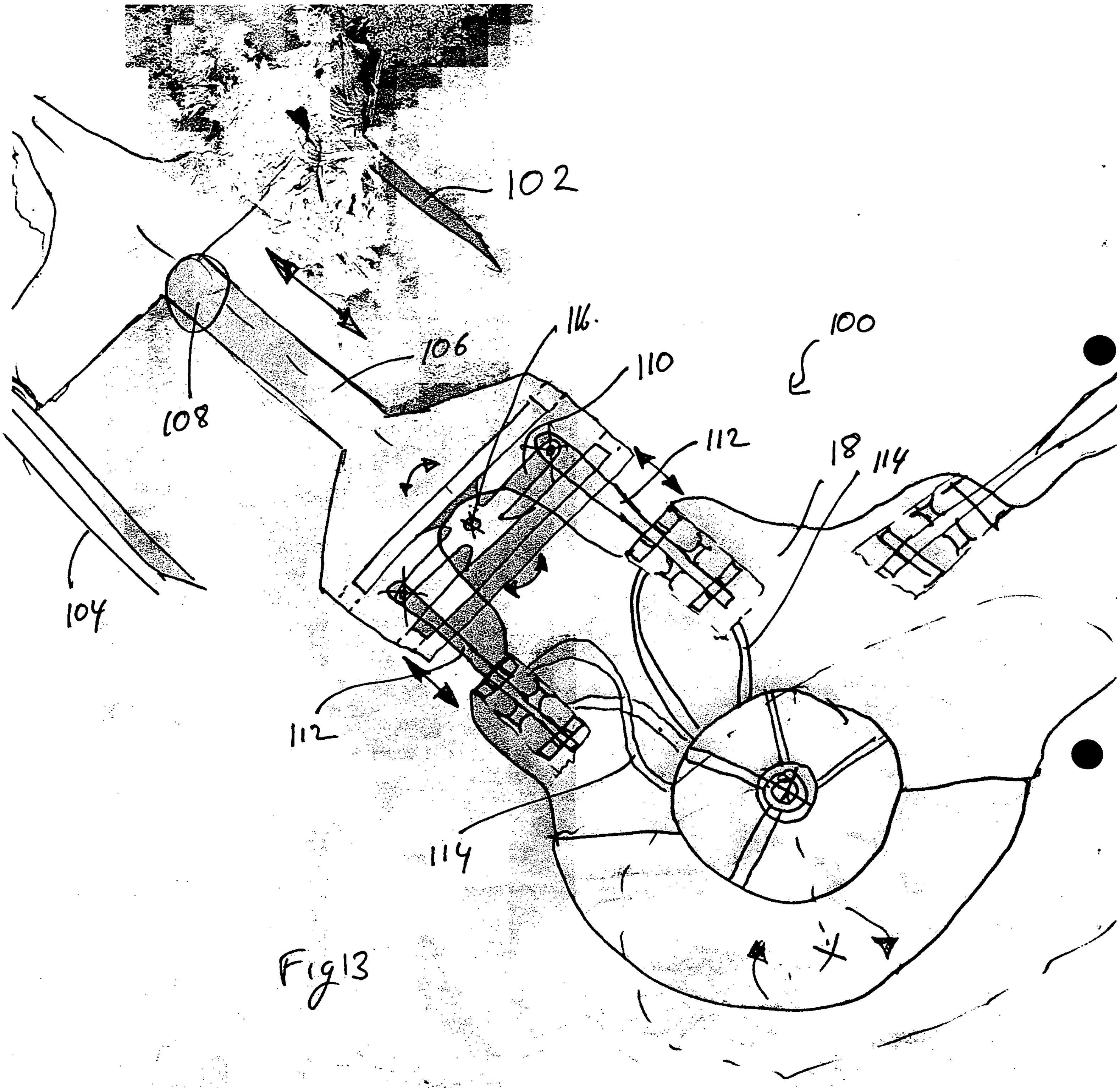


Fig13

fig 21

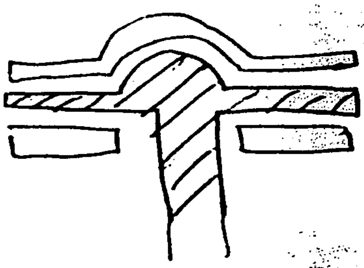


fig 14

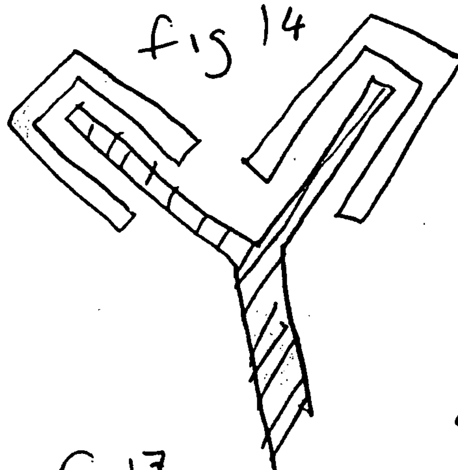


fig 15

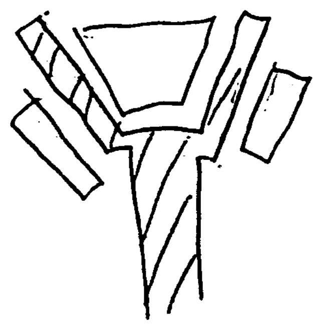


fig 22

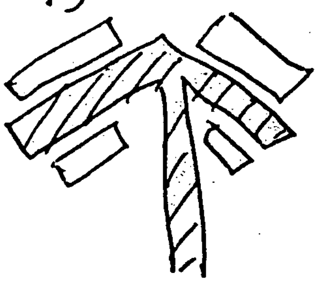


fig 17

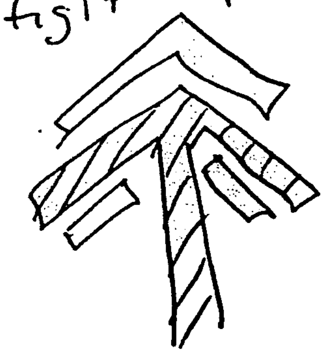


fig 16

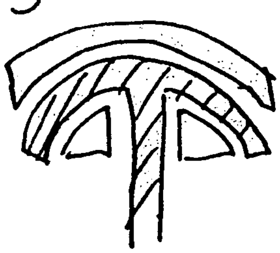
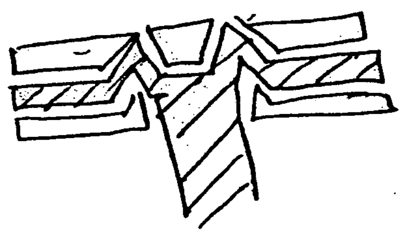


fig 18



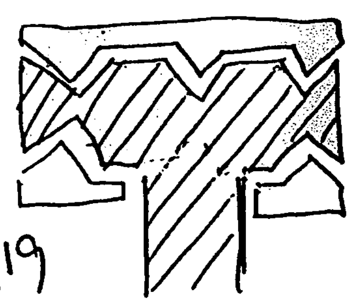


fig 19

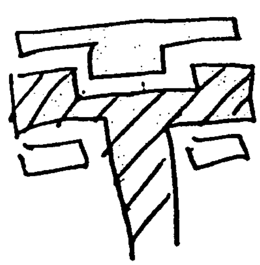


fig 20

fig 23

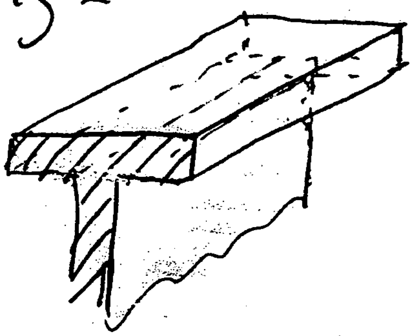


fig 24

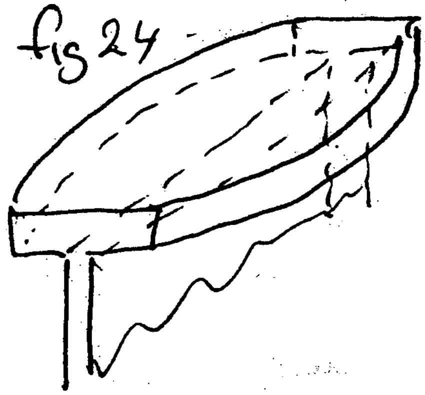


fig 25

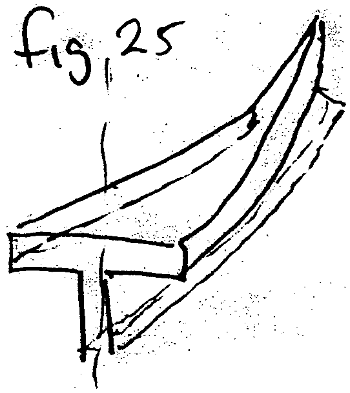
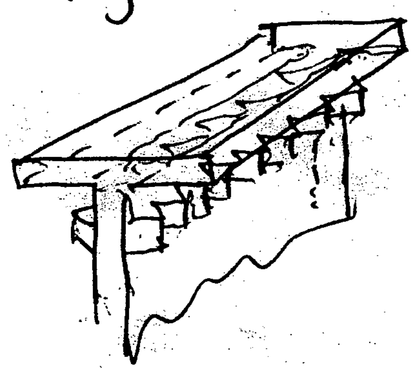


fig 26



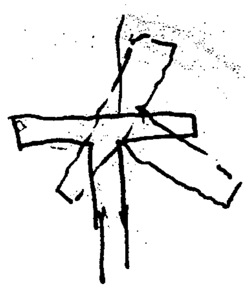


fig 27

fig 28